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THE USE OF CHEMICALS AS INSECTICIDES--PLANTS. AGRICULTURAL CHEMICALS TECHNOLOGY, NUMBER 2.

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THIS GUIDE IS ONE OF A SERIES DESIGNED TO PROVIDE GROUP INSTRUCTION AND INDIVIDUAL OCCUPATIONAL EXPERIENCE FOR POST-SECONDARY STUDENTS PREPARING FOR EMPLOYMENT AS AGRICULTURAL CHEMICAL TECHNICIANS. IT WAS DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF STATE STUDY DATA. THE OBJECTIVES ARE TO DEVELOP (1) INTEREST, APPRECIATION, AND UNDERSTANDING OF CHEMICAL USE IN INSECT AND PEST CONTROL, (2) ABILITY TO COMMUNICATE, STUDY, COMPUTE, AND MEASURE IN THE FIELD, (3) ABILITY TO RECOGNIZE AND IDENTIFY INSECTS, PESTS, AND DAMAGE SYMPTOMS, (4) KNOWLEDGE OF CHEMICALS, (5) KNOWLEDGE OF PRINCIPLES AND CONCEPTS UNDERLYING CHEMICAL USE, AND (6) KNOWLEDGE AND SKILL IN LAWFUL AND SAFE HANDLING OF CHEMICALS. SUGGESTIONS FOR INTRODUCING THE COURSE ARE GIVEN. EACH MAJOR UNIT INCLUDES OBJECTIVES, TEACHER PREPARATION, TEACHING-LEARNING ACTIVITIES, INSTRUCTIONAL MATERIALS AND REFERENCES, AND, IN SOME CASES, EVALUATIVE CRITERIA IN THE FORM OF SPECIFIC STUDENT PERFORMANCES. THE MODULE IS DESIGNED FOR 24 HOURS OF CLASS INSTRUCTION, 36 HOURS OF LABORATORY EXPERIENCE, AND 120 HOURS OF OCCUPATIONAL EXPERIENCE. TEACHERS SHOULD HAVE A BACKGROUND, AND STUDENTS AN OCCUPATIONAL GOAL, IN AGRICULTURAL CHEMICALS. THIS DOCUMENT IS AVAILABLE FOR A LIMITED PERIOD FOR $6.75 PER SET (VT 001 214 - 001 222) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212. (JM)

THE USE OF CHEMICALS AS INSECTICIDES--PLANTS

AGRICULTURAL CHEMICALS TECHNOLOGY
No. 2

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

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M E M O R A N D U M

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FROM: (Person) James E. Hensel (Agency) The Center for Vocational and Technical Education

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DATE: August 7, 1967

RE: (Author, Title, Publisher, Date) **Module No. 2, "The Use of Chemicals as Insecticides - Plants," The Center for Vocational and Technical Education, December, 1965.**

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(3) Utilization of Material:
Appropriate School Setting Post High School
Type of Program Intensive, full-time, two-year, technician program
Occupational Focus Goal in the Agricultural Chemicals Industry
Geographic Adaptability Nationwide
Uses of Material Instructor course planning
Users of Material Teachers

(4) Requirements for Using Material:
Teacher Competency Background in agricultural chemicals
Student Selection Criteria Post high school level, aptitude in chemi., high school prerequisite, goal in the agricultural chemicals industry.
Time Allotment Estimated time listed in module. (P)

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Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

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(address)

This publication is a portion of the course material written in Agricultural Chemicals Technology. To be understood fully, the complete set of materials should be considered in context. It is recommended that the following order be observed for a logical teaching sequence:

#1 - The Use of Chemicals as Fertilizers

#2 - The Use of Chemicals as Insecticides - Plants

#3 - The Use of Chemicals as Soil Additives

#4 - The Use of Chemicals as Fungicides, Bactericides and Nematocides

#5 - The Use of Chemicals to Control Field Rodents and Other Predators

#6 - The Use of Chemicals as Herbicides

#7 - The Use of Chemicals in the Field of Farm Animal Health (Nutrition, Entomology, Pathology)

#8 - The Use of Chemicals as Plant Regulators

TABLE OF CONTENTS

THE USE OF CHEMICALS AS INSECTICIDES - PLANTS

Major Teaching Objective

To develop personal qualities and effective abilities needed for entry by technicians in occupations which have to do with the use of chemicals in the field of plant entomology.

Suggested Time Allotment

At School

Class Instruction	24 hours	
Laboratory Experience	36 hours	
Total at School		60 hours
Occupational Experience (over a two-year period)		120 hours
Total for Course		180 hours

Suggestions for Introducing the Course

The field of insects and similar pests which infest plants is considered to be of such magnitude as to require treatment as a unit of study by itself in this technical curriculum. Insecticides are commonly classified as pesticides and included in the same category as other chemicals such as herbicides, nematocides, fungicides, bactericides, rodenticides, etc. However, each of these pesticides, along with the appropriate field of agriculture, is considered to be of such importance to the field of agricultural chemicals technology that detailed study is required.

1. From information obtained from workers in industry, business, public service, and education develop with the students a list of the skills, abilities, and understandings which agricultural chemical technicians need for employment in the insecticide industry. The list will include entries for each of the following subheadings:

   a. Man's use of chemicals to attempt to control insects which infest plants.

   b. Federal, state, and local laws, regulations, and controls which pertain to the sale and use of insecticides.

c. The recognition and identification of insects, insect damage, and situations of potential danger due to infestation.

d. Various chemical resources available for use to control, prevent, or eradicate insects.

e. The understandings and principles of soil science, entomology, chemistry, and plant growth which are needed to effectively control plant infesting insects.

f. Skills, abilities, and understandings needed to modify a situation or problem brought about or caused by insects (or the threat of infestation).

g. Important terms, definitions, nomenclature, tables, charts, guides used, and important computations, calculations, conversions, and measurements performed.

h. The handling and application of insecticides, in the proper manner, using approved methods and equipment.

2. List groups of activities in which technical workers engage doing work in the field of insect control.

3. Develop a list of factors which tend to complicate the task of controlling insects which infest plants.

a. Expense of control program (chemicals, equipment, application).

b. Resistance of some insects to chemicals.

c. Difficulty with drift and residues.

d. Ineffectiveness of some chemicals.

e. Damage may be serious before control can be instituted in many cases.

f. Danger of destroying beneficial insects.

g. Application of insecticides difficult or impossible during certain times of the year.

4. Determine with the students the various kinds of insecticides that are available from local firms for controlling insects which infest plants.

a. Poisons - stomach

b. Poisons - contact

c. Fumigants

d. Attractants

e. Repellents

5. Have the student react (research may be appropriate) to three questions:

   a. Up until about 1940, what measures were used to control insects (plant infesting)?

   b. From about 1940 until the present, what control measures have been used to control insects (plant infesting)?

   c. What means do you think we will be using to control insects in 1975?

Competencies to be Developed

I. To develop an interest in and an appreciation and understanding of man's use of chemicals to attempt to prevent, control, or eradicate insects and similar pests which infest plants.

Teacher Preparation

Subject Matter Content

Note: A review of important teachings of entomology, chemistry, and crop production classes insofar as they relate to a study of insecticides. An examination of the magnitude and importance of the insect problem confronting man and the attempts he has made to modify the problem in his favor.

1. Examination of the Problem or Setting.

a. "Every minute of the day and night billions of insects are chewing, sucking, biting, and boring away at our crops . . ." (pp. 141-146, Insects, U.S.D.A.).

The amount of damage done is hard to estimate because of so many variables and complicated factors. Variations are found from year to year and from one area to another. The U.S.D.A. estimates the annual loss to farm crops due to pests to be five billion dollars. (Placed end-to-end, five billion one dollar bills would reach around the earth about eighteen times.) Scientists have estimated that as much as 90 per cent of the food man grows would be destroyed if he did not constantly control pests. The over-all picture is one of great expense to human beings who must depend upon plants for survival and thus must compete with other forms of life for the use of these plants. Man is an integral part of the balance of nature. This balance is constantly shifting, and if man did not continually exert effort to maintain his position, he would drop to a much lower status or even perish. We usually notice only those pests which cause rather obvious and sudden symptoms on desirable plants. There are, however, numerous pests which do not cause severe damage, but affect the plants by continually sapping a small amount of vitality from them. Over a period of time, this causes a decline in the condition of the plant which in turn affects its production.

b. Insect pests affect us in the following ways:

1) Reduce the yields

2) Lower the quality

3) Increase the cost of production and harvesting

4) Require outlays for materials and equipment to apply control measures

5) Increase processing costs

6) Transmit disease, viruses, bacteria, fungi, and parasites

7) Other

2. Possible courses of action

a. Methods of controlling plant infesting insects

We know of no species of insect which has disappeared from the earth because of man's activities. Control methods are usually in one of three basic areas: Exclusion, Eradication, or Protection. A few methods are:

1) The use of chemicals

2) The use of resistant plants

3) Using cultural practices of field sanitation, cultivation, crop rotation, weed control, etc.

4) The use of biological controls - other insects, disease, parasites, and predators

5) Sterilization of males

6) Vapor - heat process, cold treatment

7) Traps, attractants

8) Radiant energy

9) Environmental control (air, light, minerals, temperature, water)

10) Physical barriers (cheese cloth, plastic, aluminum foil edging)

3. The use of chemicals to control plant infesting insects

Note: Poisons affect the normal functions of specific cells and tissues of insects just as they are known to do in humans. The application of pesticides is usually done as a preventative measure although it is not uncommon to encounter pests in the field which require eradication measures.

a. Kinds of insecticides available are classified according to the way they get into the insect's body cavity.

1) Stomach poisons - are eaten

2) Contact poisons - enter through the skin

3) Fumigants - enter through the breathing tubes or skin as gases

4) Attractants, repellents

b. Examples of well-known control program(s) in which insecticides are used. (Cite local programs if possible.)

1) Eradication of the Japanese beetle from California

2) Mediterranean fruit fly in Florida

3) Other

c. What major determinations need to be made in order to use insecticides effectively?

1) Kind of chemical to use

2) Time to use

3) Placement

4) Amount of concentrations to use

5) Method of application

6) Form of insecticide to use - liquid, dust, gas

7) Ease of application

8) Relative safety in using

9) Cost

10) Toxicity

11) Residue danger

12) Drift danger

d. What are some of the results generally obtained as a result of using insecticides?

1) Higher yields of better quality product

2) Total cost often increases but cost per unit is generally less because of increased production

3) Must assume greater risk

4) Some insects become more difficult to kill

5) Reduction in plant diseases

e. Importance of using insecticides

1) Economic considerations

2) Managerial

3) Cultural

4) A tool for efficient farming

5) A "must" in producing many crops

6) A "must" in food protection and quality preservation

7) Needs of an expanding population

8) Inadequacy of other controls

f. Problems encountered in using insecticides

1) Danger of drifts and residues to desirable plants, insects, birds, beneficial wildlife, farm animals and humans

2) Accidental poisoning of applicators

3) Inability to secure desired results

4) Increased cost of production

4. The insecticide industry

   a. History and development

      1) When did it all start? (fossil insects)

      2) How does an insect perpetuate itself so well?

      3) Early attempts to control insects

      4) Pre 1940 period

      5) 1940 - 65 era

   b. Present situation and status

      1) Numbers of insects

         a) Why do we have more insects today than ever before?

         b) How many insects are there?

      2) Number of insecticides on the market today

      3) Number of companies manufacturing insecticides

      4) The extent to which insecticides are used

   c. Recent changes and future trends

      1) The Foreword by Secretary of Agriculture, Charles F. Brannan in the 1952 Yearbook of Agriculture entitled "Insects," summarizes the subject appropriately:

> This practical book gives farmers and many other persons a great deal of information about the useful insects, as well as the harmful ones which are estimated to cost us four billion dollars a year.
>
> It is a timely book. In helping us combat our insect enemies it helps us produce more food, feed, fiber, and wood, all of which we need more than ever before.
>
> It is also a disturbing book -- and that, to me, is one of its virtues. Although, the science of entomology has made great progress in the past two decades, the problems caused by insects seem to be bigger than ever. We have more insect pests, although we have better insecticides to

use against them and better ways to fight them. Effective though our quarantines are against foreign pests, some of them are slipping through and require vigorous attention. Many aspects need to be considered in the control of insects. We must stop the destruction of our crops and forests, but the insecticides we use must leave no dangerous residues on foods, destroy no beneficial wildlife, and do no damage to our soils.

We thought we had some of the problems solved when we got such a good result from the new insecticides. DDT, for example, made medical history in 1943 and 1944 when an outbreak of typhus in Naples was controlled in a few weeks by its use. Entomologists hoped then that DDT could end all insect-borne diseases and even eradicate the house fly. In less than a decade, however, DDT was found to be a failure against the body louse in Korea, and the specter of typhus hung over that area. DDT and the insecticides substituted for it failed to control mosquitoes in some places. In 1952 the house fly was no longer controlled in many places by any of the residual-type insecticides in use, and it seemed likely that other pests (those of agricultural, as well as medical, importance) in time would develop resistance.

The answer, like the challenge, is clear.

We dare not think of any knowledge--least of all knowledge of living things--as static, fixed, or finished. We need to push on to new horizons of thinking and investigation and, reaching them, see new horizons. We need a longer view in research and an appreciation that it can have two goals: First, practical, everyday results that can be expressed in terms of definite methods, tools, and advice, and, second, fundamental, basic knowledge, on which the applied science rests.

A book like this and the long research that made it possible exemplify the first goal. But if we are to progress further in this vital work, we need to keep the second goal always before us, remembering that science and knowledge are ever-growing and ever-changing.

2) Effect of rapid changes in insecticide industry

3) Insecticides in the future

Suggested Teaching-Learning Activities

1. Secure a listing of all the different insecticides for plant infesting insects that are available locally. Indicate brands, trade names, active ingredient, company, and instructions for use. Small packages or containers with original labels will enhance effectiveness of the study. Adequate safety precautions should be taken in handling the containers.

2. In cooperation with a local grower on his farm:

   a. Determine the insect control program being used.

   b. Ascertain the approximate value from having used insecticides on the farm during one season.

   c. Examine and describe as many kinds of insect damage as can be found on the farm.

   d. Study the equipment and supplies used on the farm to control insects.

3. Determine the approximate amounts of insecticides used annually at the local, state, and national level. What was the cost of these amounts and what values accrued because of their use? (Approximate)

4. Demonstrate the toxicity and lethal effects of one of the well-known insecticides. Use only the smallest amount possible to show effectiveness.

5. Conduct a pesticide survey (with the class) of farmers in the area. Ascertain what problems in the field of pesticides and pests that have been most commonly encountered.

Suggested Instructional Materials and References

Insects, Yearbook of Agriculture, U.S.D.A., U. S. Government Printing Office, Washington, D.C., 1952.

Agricultural Chemicals, Manufacturing Chemists' Association, Inc., Washington, D.C., 1963. (Price 25¢)

The Necessity, Value and Safety of Pesticides, L. A. McLean, Secretary, Velsicol Chemical Company, Chicago, Illinois.

"The Unseen Harvester," DuPont 16mm sound film.

Record and film strip "Facts About Pesticides," Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N.W., Washington, D.C.

Chemical and insect speciman to demonstrate toxicity and lethal effects of an insecticide.

Labels and empty containers.

II. To develop the ability to use important terms, nomenclature, definitions, tables, charts, and guides which are commonly used and also to develop the ability to perform important computations, conversions, calculations, and measurements which are commonly done by technical workers in the field of plant entomology.

Teacher Preparation

Subject Matter Content

Note: This unit is presented here at an early point in the study guide in order that use can be made of materials covered herein throughout the remainder of the course. It is not intended that it will be taught as a separate competency, as are the other six major units of the course, but that the material presented here will be integrated as appropriate throughout the remainder of the study. The purpose of this section, then, is to pull together in one section this core of information.

1. Terms, nomenclature, and definitions

   a. Pfadt, Fundamentals of Entomology - Contains an appendix of common scientific names of insects and a glossary of terms and words.

   b. A comprehensive pesticide dictionary is included in the 1966 Farm Chemicals Handbook.

   c. A Glossary of Pesticide Terms is a part of the presentation in Agricultural Chemicals. Useful Pesticide Formulas are also presented.

   d. Pesticide definition as used in California. (May vary from state to state.)

      "Pesticides (legally defined 'economic poisons' in Section 1061 of the Agricultural Code) are substances or mixtures of substances intended to be used for controlling, preventing, destroying, repelling, or mitigating any pest. The term is not limited to materials highly toxic to human beings or livestock, which are thought of as 'poisons' but includes insecticides, fungicides, rodenticides, herbicides, vermicides, defoliants, wood-preservatives, pre-harvest desiccants, repellents, anti-fouling paints, and mildew-controlling paints, as well as substances for control of snails, predatory animals, injurious birds, bacteria, algae, soil-infecting nematodes, and other undesirable forms of plant and animal life."

2. Tables, guides, and computations

a. Conversion tables

1) Weight

1 ounce (oz) = 16 drams (dr) = 28.35 grams (gm)

1 pound (lb) = 16 ounces (oz) = 453.59 grams

1 short ton = 2000 pounds

2) Liquid measure

1 fluid ounce (fl. oz.) = 29.57 milliliters (ml.)

1 gill = 4 fluid ounces

1 pint (pt.) = 4 gills = 0.47 liter (l.)

1 quart (qt.) = 2 pints = .95 liter

1 gallon (gal.) = 4 quarts = 3.79 liters

3 teaspoons = 1 tablespoon

2 tablespoons = 1 fluid ounce

16 tablespoons)

2 gills) = 1 cup

1/2 pint)

8 fluid ounces)

1 Kilogram = 2.2 pounds

3) Dry measure

1 pint = 0.55 liter

1 quart = 2 pints = 1.1 liters

1 peck (pk.) = 8 quarts

1 bushel (bu.) = 4 pecks

4) Measure of length

1 inch (in.) = 25.4 millimeters (mm.) = 2.54 cm.

1 foot (ft.) = 12 inches = 30.48 centimeters (cm.)

1 yard (yd.) = 3 feet = 0.91 meters (m.)

1 rod (rd.) = $16\frac{1}{2}$ feet = 5.5 yards = 5.03 meters

1 mile (mi.) = 5280 feet = 320 rods = 1.61 kilometers (km.)

5) Area measurement

1 square inch (sq.in.) = 6.45 square centimeters (cm^2)

1 square foot (sq.ft.) = 144 square inches = 0.000023 acre

1 square yard (sq.yd.) = 9 square feet

1 square rod (sq.rd.) = 30.25 square yards = 272.25 square feet

1 acre (A.) = 160 square rods = 43,560 square feet

1 square mile = 640 acres

1 acre = 4840 square yards

1 acre = 209 feet square (approx.)

1 hectare = 2.471 A.

6) Cubic measurement

1 cubic inch (cu.in.) = 16.39 cubic centimeters (cc.)

1 cubic foot (cu.ft.) = 1728 cubic inches

1 cubic yard (cu.yd.) = 27 cubic feet

7) Commonly used equivalents

1 gallon = 231 cubic inches

1 cubic foot of water = 62.4 pounds

1 gallon of water = 8.33 pounds

1 pint of liquid per 100 gallons = 1 teaspoon per gallon (approx.)

1 meter = 39.37 inches

1 cubic foot = 1728 cubic inches

1 cubic foot = 0.8 bushel

1 cubic foot = 7½ gallons

1 teaspoon = 4 cubic centimeters

1 tablespoon = 15 cubic centimeters

1 cup = 120 cubic centimeters

1 mile per hour (mph) = 88 feet per minute (fpm)

8) Rates of application

1 ounce/square foot = 2722.5 pounds/acre

1 ounce/square yard = 302.5 pounds/acre

1 ounce/100 square feet = 27.2 pounds/acre

1 pound/100 square feet = 435.6 pounds/acre

1 gallon/acre = 1/3 ounce/1000 square feet

b. Quantity of material to use

1) Recommendations are often given on the basis of pounds of total formulated material per 100 gallons. Equivalent dilutions in smaller quantities are given in the following table.

100 Gallons	10 Gallons	5 Gallons	3 Gallons	1 Gallon	1 Quart
		Powdered Materials			
8 oz.	0.8 oz.	0.4 oz.	6.8 g.	2.2 g.	0.6 g.
1 lb.	1.6 oz.	0.8 oz.	13.6 g.	4.5 g.	1.1 g.
2 lb.	3.2 oz.	1.6 oz.	27.7 g.	9.1 g.	2.3 g.
3 lb.	4.8 oz.	2.4 oz.	1.4 oz.	13.6 g.	3.4 g.
4 lb.	6.4 oz.	3.2 oz.	1.9 oz.	18.2 g.	4.5 g.
5 lb.	8.0 oz.	4.0 oz.	2.4 oz.	22.7 g.	5.7 g.
		Liquid Materials			
1 pt.	1.6 fl.oz.	0.8 fl.oz	14.2 cc.	4.7 cc.	1.2 cc.
1 qt.	3.2 fl.oz.	1.6 fl.oz.	28.4 cc.	9.5 cc.	2.4 cc.
1 gal.	12.8 fl.oz.	4.2 fl.oz.	3.8 fl.oz.	1.3 fl.oz.	9.5 cc.
2 gal.	25.6 fl.oz.	12.8 fl.oz.	7.7 fl.oz.	2.6 fl.oz.	18.9 cc.
3 gal.	38.4 fl.oz.	19.2 fl.oz.	11.5 fl.oz.	3.9 fl.oz.	28.4 cc.
4 gal.	51.2 fl.oz.	25.6 fl.oz.	15.4 fl.oz.	5.1 fl.oz.	1.3 fl.oz.
5 gal.	64.0 fl.oz.	32.0 fl.oz.	19.2 fl.oz.	6.4 fl.oz.	1.6 fl.oz.

2) Recommendations may be on the basis of the weight of active ingredient per 100 gallons. The label on the container will state the percentage of the toxicant used. The quantity of material to use at equivalent dilution in smaller quantities can be determined by multiplying the quantity derived in (1) above by the proper factor given in this section.

	Per cent of active ingredient							
	2	5	10	20	25	40	50	75
Factor	50	20	10	5	4	$2\frac{1}{2}$	2	1-1/3

Example: A recommendation calls for applying a spray containing DDT at the rate of 3 pounds per 100 gallons (active ingredient basis). You may desire to make up 3 gallons of spray using a wettable powder known to contain 25 per cent DDT. The dilution table above indicates that 1.4 ounces per 3 gallons is equivalent to 3 pounds per 100 gallons. The factor to use for a material containing 25 per cent active ingredient is found to be 4. Multiplying 1.4 by 4 equals 5.6 ounces, the quantity of wettable powder to use.

3) Recommendations are also made to use a certain percentage concentration of the toxicant in 100 gallons. The following table tabulates certain of these concentrations.

Insecticide Formulation	Amount of Formulation Needed Per 100 Gallons of Water to Obtain the Following Percentages of Actual Chemical				
	0.25%	0.5%	1%	2%	5%
25% wettable powder	8 lb.	16 lb.	32 lb.	64 lb.	160 lb.
50% wettable powder	4 lb.	8 lb.	16 lb.	32 lb.	80 lb.
75% wettable powder	2-2/3 lb.	5-1/3 lb.	10-2/3 lb.	21-1/3 lb.	53-1/3 lb.
12% emulsion concentrate, 1 lb. active ingredient per gal.	2-1/12 gal.	4-1/6 gal.	8-1/3 gal.	16-2/3 gal.	41-2/3 gal.
20% emulsion concentrate, 1½ lb. active ingredient per gal.	1-1/4 gal.	2-1/2 gal.	5 gal.	10 gal.	25 gal.
25% emulsion concentrate, 2 lb. active ingredient per gal.	1 gal.	2 gal.	4 gal.	8 gal.	20 gal.
45% emulsion concentrate, 4 lb. active ingredient per gal.	1/2 gal.	1-1/8 gal.	2-1/4 gal.	4-1/2 gal.	11-1/4 gal.
75% emulsion concentrate, 8 lb. active ingredient per gal.	1/3 gal.	2/3 gal.	1-1/3 gal.	2-2/3 gal.	6-2/3 gal.

The number of pounds of wettable powder to be used in any spray or dip of a given percentage can be calculated by the use of the following formula:

$$\frac{\text{Number of gallons of spray} \times 8.34 \times \text{Per cent toxicant desired in spray}}{\text{Per cent toxicant in the wettable powder}} = \text{Pounds of material to be used}$$

Example: 500 gallons of dip containing 0.25 per cent DDT is needed. The wettable powder to be used contains 50 per cent DDT.

$$\frac{500 \times 8.345 \times 0.25}{50} = 21 \text{ lbs. wettable powder}$$

4) To determine the volume in gallons of an emulsion or solution concentrate, for which the percentage of toxicant by weight is known, to be used in making up an emulsion of a given percentage of toxicant by weight, use the following relationship:

$$\frac{\text{Number of gallons of spray to be made} \times \text{Per cent of toxicant desired}}{\text{Per cent toxicant in concentrate} \times \text{Specific gravity of concentrate}} = \text{Gallons needed}$$

Example: 100 gallons of spray containing 2 per cent chlordane by weight is to be prepared from an emulsion concentrate containing 40 per cent chlordane having a specific gravity of 1.00.

$$\frac{100 \times 2}{40 \times 1.02} = 4.9 \text{ gallons concentrate (+ water to make 100 gallons)}$$

5) Pounds of toxicant per acre

a) The weight of toxicant in a gallon of concentrate is determined if the percentage of toxicant and specific gravity are known.

$$\frac{8.345 \times \text{S.G.} \times \text{Percentage of toxicant}}{100} = \text{Pounds of toxicant}$$

Example: A chlordane emulsion concentrate containing 45 per cent chlordane by weight and having a specific gravity of 1.07 is to be used. Each gallon of concentrate contains

$$\frac{8.345 \times 1.07 \times 45}{100} = 4 \text{ pounds of chlordane}$$

b) The quantity of insecticide to give specific amounts of active ingredient per acre for selected chemicals is tabulated in the following table.

Insecticide Formulation	Amount of Formulation Needed Per Acre to Obtain the Following Amounts of Active Chemical Per Acre				
	1/8 lb.	1/4 lb.	1/2 lb.	3/4 lb.	1 lb.
1% dust	12-1/2 lb.	25 lb.	50 lb.	75 lb.	100 lb.
5% dust	2-1/2 lb.	5 lb.	10 lb.	15 lb.	20 lb.
10% dust	1-1/4 lb.	2-1/2 lb.	5 lb.	7-1/2 lb.	10 lb.
25% wettable powder	1/2 lb.	1 lb.	2 lb.	3 lb.	4 lb.
40% wettable powder	1/3 lb.	2/3 lb.	1-1/4 lb.	7/8 lb.	2-1/2 lb.
50% wettable powder	1/4 lb.	1/2 lb.	1 lb.	1-1/2 lb.	2 lb.
75% wettable powder	1/6 lb.	1/3 lb.	2/3 lb.	1 lb.	1-1/3 lb.
10-12% emulsion concentrate, 1 lb. active ingredient per gal.	1 pt.	1 qt.	2 qt.	3 qt.	1 gal.
15-20% emulsion concentrate, 1-1/2 lb. active ingredient per gal.	1/3 qt.	2/3 qt.	1-1/3 qt.	2 qt.	2-2/3 qt.
25% emulsion concentrate, 2 lb. active ingredient per gal.	1/2 pt.	1 pt.	1 qt.	3 pt.	2 qt.
40-50% emulsion concentrate, 4 lb. active ingredient per gal.	1/4 pt.	1/2 pt.	1 pt.	1-1/2 pt.	1 qt.
60-65% emulsion concentrate, 6 lb. active ingredient per gal.	1/6 pt.	1/3 pt.	2/3 pt.	1 pt.	1-1/3 pt.
70-75% emulsion concentrate, 8 lb. active ingredient per gal.	1/8 pt.	1/4 pt.	1/2 pt.	3/4 pt.	1 pt.

6) To determine the weight of insecticidal material (dust) to be used in preparing a dust containing a given percentage of toxicant, the following formula is useful:

$$\frac{\text{Per cent of toxicant desired} \times \text{Pounds of dust to be made}}{\text{Percentage of toxicant in material being used}} = \text{Pounds needed}$$

Example: One hundred pounds of dust containing 0.5 per cent rotenone is to be prepared. The powdered root to be used contains 4 per cent of rotenone. The quantity of powdered root is:

$$\frac{0.5 \times 100}{4} = 12.5 \text{ pounds}$$

Sufficient diluent is added to make 100 pounds

7) Sprayer calibration

a) Method I

The volume of solution applied per acre depends upon the pressure, speed of vehicle, and size of nozzle tip orifice. The following method can be used to calibrate the gallons-per-acre output.

-- Space nozzles, if possible, for the type of spraying to be done in the field (band or over-all coverage).

-- Fill supply tank.

-- Begin spraying, at a standstill, and set pressure regulator to desired pressure.

-- Stop. Refill tank and spray over a known distance, at least several hundred feet, at operating speed.

-- Measure the amount of water it takes to refill tank.

-- Determine the gallons per acre the sprayer is putting out for that pressure, speed, and orifice size with following formula:

$$\text{gallons per acre} = \frac{\text{Gallons of water to refill tank} \times 43{,}560}{\text{Width of area actually sprayed} \times \text{distance}}$$

Example 1:

$$60 \text{ gallons per acre} = \frac{6 \text{ gallons} \times 43{,}560}{4 \text{ feet} \times 1089 \text{ feet}}$$

b) Method II

For truck crop and field sprayers

-- Set two stakes 220 yards apart (660 feet)

-- Fill sprayer tank with water. Operate the sprayer to be sure the entire supply line up to the shut-off valve is full before finally filling the tank and recording the water line on a measuring stick.

-- Drive sprayer round trip between stakes (440 yards total) at the desired speed and with the sprayer in full operation. The sprayer should be moving at normal speed with pressure up, and the valve should be opened as it passes the first stake in each direction. Mark the throttle setting.

-- Carefully measure the amount of water required to refill the tank after the test. Before refilling to the same mark on the measuring stick, be sure that the sprayer is in the same location as for the first filling or is resting level in both instances to avoid possible error.

-- Multiply gallons used to refill tank by 33 and divide by width sprayed in feet. This gives gallons per acre applied.

Example: Assume it is desired to apply a spray material at the rate of 10 g.p.a., traveling at a forward speed of 5 m.p.h. and with a boom 20 feet long. If 5 gallons of water were required to refill the tank after the calibration, then the actual rate of application is determined as follows:

$$\text{g.p.a.} = \frac{5 \times 23}{20} = 8.2 \text{ gallons per acre}$$

Since this rate of application is lower than desired, the forward speed must have been greater than 5 m.p.h. Therefore, the test should be repeated using a throttle setting which will give a slightly slower rate of travel.

8) Compatibility Guides

a) A comprehensive spray compatibility chart is available from Farm Chemicals, Meister Publishing Co., Willoughby, Ohio.

9) Dilutions

EQUIVALENT QUANTITIES OF LIQUID MATERIALS
FOR DILUTION IN PARTS OF WATER

Quantity of Water Gallons	Dilution					
	1 to 200	1 to 400	1 to 600	1 to 800	1 to 1000	1 to 1600
100	2 qt.	1 qt.	2/3 qt. (21.3 fl. oz.)	1 pt.	12.8 fl. oz.	1/2 pt.
25	1 pt. (16 fl. oz.)	8 fl.oz. (1 cup)	1/3 pt. (5.3 fl. oz.)	4 fl.oz. (1/2 cup)	3.2 fl. oz.	2 fl. oz.
5	3.2 fl. oz.	1.6 fl. oz.	1.4 fl. oz.	0.8 fl. oz.	0.64 fl. oz. (3-3/4 tsp.)	0.4 fl. oz. (2-1/2 tsp.)
1	4 tsp. (18.9 ml.)	2 tsp. (9.5 ml.)	1-1/2 tsp. (6.3 ml.)	1 tsp. (4.7 ml.	3/4 tsp. (3.8 ml.)	1/2 tsp. (2.4 ml.)

NOTE: The instructor may wish to use the following outline to summarize data provided for in this section.

SECTION ONE - General Information

THE STUDENT WILL NEED TO BE ABLE TO:

1. Make use of words, terms, and phrases appropriate to the subject matter of the course. A Glossary of Terms will facilitate this usage.

2. Perform measurements, conversions, computations, and calculations commonly done by technical workers in the field. Tables containing units of measurement and tables of equivalents of units will be useful.

   a. Tables of measurement

      -- Linear measure - length

      -- Square measure - area

      -- Cubic measure - volume

      -- Liquid measure - capacity

      -- Dry measure - capacity

      -- Weight measure

      -- Temperature measure

      -- Time measure

      -- Other

   b. Tables of convenient equivalents

      -- Equivalent volumes - liquid measure

      -- Equivalent volumes - dry measure

      -- Equivalent weight/volume - liquid

      -- Equivalent weight/volume - dry

      -- Equivalent lengths

      -- Equivalent areas

      -- Equivalent weights

      -- Equivalent temperatures

      -- Equivalent other

SECTION TWO - Information Regarding Agricultural Chemicals

THE STUDENT WILL NEED TO MAKE USE OF:

1. A table which lists the common name, active ingredient, and trade name(s) of chemicals studied in the course.

   Example: EDB Ethylene dibromida Soil fume, Dew fume I0-85

2. An alphabetical listing of chemicals commonly used in the field. Information such as the trade name, name of major producer, composition, formulation, and recommended use.

   Example: D - D (Shell)

   1, 3-dichloropropane, 1, 2-dichloropropane and other related hydrocarbons; a nematocide for soil fumigation.

3. A listing of chemical materials according to the general use.

   Example: Nematocides

   -- chloropicrin

   -- DECP

   -- D-D

   etc.

   Rust Fungicides

   -- ferbam

   -- sulfur

   -- maneb

   etc.

4. Compatibility charts and tables

   a. Phytotoxicity (with plants)

   b. Chemicals (with other chemical)

   c. Physical (with other chemical)

5. Toxicity tables providing LD and LC values (both oral and dermal, acute and chronic) of chemicals studied in the course.

6. Tolerance limitations imposed by F.D.A. upon residues applicable to the subject matter of the course (i.e., herbicides, insecticides, fungicides, etc.)

What is one part per million?

Most lay people have no conception of what constitutes one part per million residue on crops. The following examples may help you make this interpretation for them:

1. One inch is one part per million in 16 miles.
2. A postage stamp is one part per million of the weight of a person.
3. A one gram needle in a one ton hay stack is 1 ppm.
4. One part per million is one minute in two years.
5. Lay your hand on the ground and it covers 5 ppm of an acre.
6. If one pound of a chemical lands on an acre of alfalfa the hay has 500 ppm. One ounce of a chemical would impart 31 ppm.
7. A teaspoon of material on an acre of alfalfa would impart 5 ppm.
8. One teaspoon of DDT drifting onto 5 acres of alfalfa puts 1 ppm in the hay, and the Federal law says that the hay must contain none.

(Source--Western Crops and Farm Management)

SECTION THREE - Preparation of Chemicals for Use

THE STUDENT WILL NEED TO BE ABLE TO:

1. Determine whether or not materials prepared and commercially packaged can be applied directly from the container.

2. Determine the total amount(s) of active ingredient(s) contained in a chemical mixture. Mixtures may vary according to weight, volume, concentration, and formulation.

3. Make a determination of the amounts, by weight or by volume, of chemical materials of various levels of concentration to use in order to prepare a given quantity of mixture that will meet recommended or specified dosage or concentration levels. (Weights or volumes of solid or liquid chemicals required to prepare a given quantity of material of different dilutions.)

4. Interpret tables and recommendations for "concentrate" spraying.

SECTION FOUR - Preparation Necessary in Order to Secure Specified or Recommended Application Rates

THE STUDENT WILL NEED TO BE ABLE TO:

1. Compute the area of various plots of land. These plots will vary in size, shape, topography, and planting.

   a. Determine acreage of row planting which vary according to spacing.

   b. Determine total acreage of plots.

2. Determine the speed of a vehicle traveling on the land. (In miles per hour and feet per minute.)

3. Three variables affect the application rate of agricultural chemicals secured in the field - the speed of travel, the effective width of the device applying the chemical, and the total material delivered per unit of time. If two of these variables are known, calculate the other in order to secure a specific application rate.

   a. Calibrate sprayers, dusters or metering devices to secure specific delivery rates.

   b. Compute the length of boom, number of outlets, or width of opening to secure specific widths.

   c. Calibrate ground speed to secure specific rate of forward travel.

4. Use tables of "Rate of Equivalents."

   Example: 1 ounce per square foot = 2722.5 pounds per acre

5. Calculate the quantity of spray per length of row (on various spacings) which will be equivalent to a specific application per acre.

6. Determine the gallons per acre required to spray orchards of different planting distances.

7. Consider the effect of particle size on drift and deposit. (Prepare spray drift and deposit table.)

SECTION FIVE - Information Relative to Diagnosis and Prescription

THE STUDENT WILL NEED TO MAKE USE OF:

1. Tables, charts, and guides which summarize situations encountered in agricultural production in which the use of

chemicals is appropriate. Materials to use and methods of application are suggested.

Examples of form used:

Plant or Soil	Pest, Disease or Condition	Causative Agent or Factor	When to Treat	What Material to Use
Alfalfa	Insect	Spotted Alfalfa Aphid	At time of planting	Thimet

Active Ingredient Per Acre	Formulation	Amount Concentration Req'd Per Acre	Method of Application	Remarks
1 lb.	Granules	10% 10 lbs.	Broadcast and work in soil with seed	Do not treat if there is no spotted aphid problem in the area at time of planting, if daytime temperatures are so low that winged aphids are not migrating, or when reseeding old stands of alfalfa hay

2. Graphs, charts, tables, and other illustrative materials available and supportive of the unit under consideration.

   Examples:

   a. Graphical relationships

      -- time versus residue levels

      -- rates of application versus levels of effectiveness

      -- levels of concentration versus levels of effectiveness

      -- stage of development or growth versus effectiveness of chemical control, etc.

Suggested Teaching-Learning Activities

1. Prepare useful tables, charts, and guides for use in class by having students summarize the information from various sources.

2. Plan for the development of various study guides for use throughout the course. Additions should be made as the course progresses.

3. Have students actually calculate and measure out solid and liquid dilutions of chemicals.

Suggested Instructional Materials and References

Agricultural Chemicals, W. T. Thompson, The Simmons Publishing Company, Davis, California, 1964.

Farm Chemicals Handbook, Meister Publishing Co., 37841 Euclid Ave., Willoughby, Ohio, 1965.

Fundamentals of Applied Entomology, The MacMillan Company, New York, 1962, Robert E. Pfadt.

Handbook for Vegetable Growers, J. E. Knott, John Wiley & Sons, Inc., New York, 1962.

Insects, Yearbook of Agriculture, U.S.D.A., Superintendent of Documents, Washington, D.C., 1952.

Destructive and Useful Insects, Metcalf, Flint, Metcalf, 4th Edition, McGraw-Hill Book Co., New York, 1962.

Guides, Handbooks, Fact Sheets, Bulletins, Leaflets, Circulars, from Federal and State Agencies and Commercial Firms.

III. To develop the ability to recognize and identify: (1) Insects and similar pests which commonly infest plants in the local area; and (2) symptoms of stress commonly encountered in plants which are the results of insect infestation.

Teacher Preparation

Subject Matter Content

Note: Symptoms of stress in a plant can be produced by a large number of factors, only one of which may be insect infestation. In some instances, the causative factor(s) is readily identifiable but very often damage caused by insects resembles, and can easily be confused, with damage caused by other factors. Important to the ability to recognize and identify insects and symptoms of stress which they cause in a plant is a knowledge of plant growth as affected by nutritional deficiencies, or excesses, water deficiencies or excesses, temperature and light variations, evaporation, transpiration, animals, sprays and dusts, weeds, disease, atmospheric pollution, nematodes and soil reaction.

1. Review

   a. Insects of local economic importance

      1) Study in detail the insects in the local and regional level which are most likely to cause damage to crops. (15-20 suggested.) Add to the following study guide as appropriate.

         a) Common name of insect

         b) Scientific name of insect

         c) Important points of life cycle to remember

         d) Type and extent of damage likely without control

         e) Type of program considered most effective

         f) Pertinent information regarding the physiology of the insect

         g) Economic importance of insect control

      2) Insect-like animals

         Mites, sowbugs, pillbugs, millipedes, slugs, snails

   b. Attributes of normal plant growth and development

2. Symptoms of stress in a plant.
   a. Recognizing insect damage and stress symptoms
      1) Color - is any part of the plant abnormal in color
      2) Size and general vigor - is the plant normal in size and vigor considering age, species, variety and other variables.
      3) Physical condition - is the plant broken, missing parts or exuding sap.
      4) Physiological - is the plant wilted or misshapen or exhibiting abnormal growth.

3. Factors often associated with insect control in plant production.
   a. Cultural practices
      1) Cleanliness of tillage
      2) Crop rotation practiced
      3) Planting dates used
      4) Field sanitation practiced
      5) Cultivation
      6) Harvesting dates and stages of maturity
      7) Placement of growing crops in relation to other crops
   b. Practices related to securing a vigorous plant.
      1) Control of plant disease, weeds, rodents
      2) Quality of seed bed preparation
      3) Quality of seed or plant stock used
      4) Selection of varieties adapted to the area
      5) Fertilization practices
      6) Control and regulation of soil moisture
      7) Use of resistant varieties
   c. Environmental factors
      1) Weather (wind, temperature, rain fall, relative humidity)
      2) Climate (long dry hot periods, high humidity, high temperature, etc.)
      3) Soil (reaction, structure, fertility level)

4. Destructive effects of insects on plants
   a. Insects can be thought of as belonging to one of three groups according to their eating habits.
      1) Those that exercise little or no choice of food depending upon availability, abundance, texture, succulence, etc.

2) Those that restrict feeding to a small and discrete number of usually similar plants.

3) Those that restrict feeding to a single species in a practical sense.

b. The eating habits of insects results in damage to plants either by chewing, sucking, biting, or boring.

c. Crop product quality is lowered by contamination of insect, insect parts and remains.

d. Some insects are destructive to a large extent in the manner in which they lay their eggs.

e. Many plant diseases are spread by means of insects.

Suggested Teaching-Learning Activities

1. Attempt to duplicate, in the laboratory, symptoms of stress in plants caused by various kinds of insects. Contrast these symptoms to those brought about by other forces or agents.

2. In field laboratory study, identify as many different evidences of plant stress symptoms as possible. Ascertain the causative factor in each case.

3. Update and improve the insect collection the student prepared in his entomology class.

4. Collect and prepare an insect specimen for shipment to an identification center.

5. Prepare mounted specimens or displays of plants showing various characteristic symptoms of stress.

Suggested Instructional Materials and References

Insects, The Yearbook of Agriculture, U.S.D.A., Superintendent of Documents, Washington, D.C., 1952.

Destructive and Useful Insects, Metcalf, Clell. L. et al. Third Edition, McGraw-Hill Book Company, 1962.

Fundamentals of Applied Entomology, Robert E. Pfadt, The MacMillan Company, New York, 1962.

Various plants and insects needed to work with in setting up various plant stress demonstrations.

IV. To become knowledgeable at the technical level regarding various chemicals commonly used as insecticides to prevent, control, or eradicate insects and similar pests which infest plants.

Teacher Preparation

Subject Matter Content

The use of chemicals in recent decades to control insects which infest plants has progressed through three distinct phases. Less than 100 years ago extensive and concerted use was made of various concoctions as could be prepared. Arsenic compounds were most often used although preparations of tobacco, pyrethrum, and sulphur were not uncommon. The successful use of arsenic compounds against the Colorado potato beetle ushered in an era of widespread use of inorganic insecticides. These were primarily compounds of antimony, arsenic, mercury, selenium, sulphur, thallium, zinc, and fluorine. Under the stimulus of World War II, wide introduction and immediate acceptance of so-called synthetic organic compounds was experienced. DDT was introduced in 1942, organophosphorus compounds in 1946 and systemic insecticide in 1950. The field is now crowded with proven and candidate materials against practically all kinds of insect pests of practically all agricultural plants. The technician in the field must have a working knowledge of these chemical resources common to the field.

1. Common types of insecticide formulation

   a. Dusts

      1) Mixed with or impregnated on walnut shell flour, talc, pryophyllite, bentonite or attapulgite. Ground to 1 to 40 microns in size (pass through a 325 mesh screen) and active materials may make up from 0.1 to 25% of the dust.

   b. Granular formulations

      1) 20/40 size means most of the granules pass through a standard 20 mesh screen and only a negligible quantity will pass through a standard 60 mesh sieve. These formulations are much like dusts except for size.

   c. Insecticide - fertilizer mixtures

      1) Granular insecticide added to commercial fertilizers or insecticide is sprayed directly onto fertilizer.

d. Wettable powders

1) Appearance like dusts but they are meant to be diluted and suspended in water and used as sprays. May contain as high as 75% toxicant.

e. Solutions

1) Materials which go into true solution - water is used for some but most organic insecticides must be dissolved in organic solvents.

f. Emulsifiable concentrates

1) Consists of insecticide, solvent, and an emulsifying agent. Oil-in-water type possible. Serves many purposes.

g. Aerosols

1) Minute particles suspended in air as fog or mist. Particle size range from 0.1 to 50 microns. The dispersion accomplished in various ways.

h. Fumigants

1) Insecticide used in the gaseous form most is often formulated as a liquid and held in a container under pressure. Upon release to the air, it changes to a gas.

i. Miscellaneous

1) Pills

2) Shampoo

3) Waxes

4) Baits

2. Classification of Insecticides

Several ways are used to classify insecticides. The student should be familiar with the basis of these classifications as well as with some of the more common insecticides in each of the categories of the classification used.

a. Based on the mode of entry into the insect.

1) Stomach poisons

a) Materials are ingested and lethal action is primarily through absorption into the digestive system (lead arsenate, calcium arsenate, sodium fluoride).

2) Contact poisons

a) Materials are absorbed through the body wall - insect must come into direct contact (chlorinated hydrocarbons, rotenone, organic phosphates).

3) Fumigant poisons

a) Enter the tracheal system in the form of a gas. (Methyl bromide, naphthalene.)

b. Based on the chemical nature of the insecticide

1) Inorganics -

A few inorganic insecticides are still used in agriculture even though most have been replaced by organic compounds.

a) Acid lead arsenate

b) Basic lead arsenate

c) Sodium fluoride

d) Cryolite

e) Sulfur

f) Sodium selenate

2) Oils -

Oils are phytotoxic but may be used on plants in emulsions.

a) Quality of oil is according to viscosity, boiling range, and degree of refinement.

b) Used primarily as solvents or carriers for insecticides.

c) Oils are insecticidal and used as

-- summer sprays, applied to trees in foliage

-- dormant sprays, applied when no foliage is present

3) Botanicals (derived from plants)

a) Attractants

b) Repellents

c) Solvents and extenders

d) Toxicants

-- Nicotine

-- Pyrethrum

-- Rotenone

-- Sabadilla

4) Synthetic organic insecticides

a) Chlorinated hydrocarbons

-- DDT

-- Methoxychlor

-- Toxaphene

-- Benzene hexachloride (BHC)

-- Lindane

-- Aldrin

-- Dieldrin

-- Chlordane

-- Heptachlor

-- Endrin

b) Organic phosphates

-- Parathion

-- TEPP

-- Malathion

-- Diaginon

-- Demeton

-- Di-syston

c) Fumigants

-- Hydrogen cyanide

-- Carbon disulfide

-- Methyl bromide

-- Ethylene dichloride

-- Carbon tetrachloride

-- Paradichlorobenzene

-- Naphthalene

-- Dichloropropane

d) Specific miticides

-- Ovex

-- Genite

-- Fenson

-- Dinitrophenols

-- Mitox

-- Kelthane

-- Aramite

e) Insect repellents - plants

-- Bordeaux mixture

f) Attractants

-- Geraniol

-- Eugenal

-- Q-Lure

-- Medlure

3. Properties and characteristics of insecticides

Agricultural chemicals technicians need to be familiar with the properties and characteristics of commonly used insecticides. It is suggested that the instructor select appropriate chemical compounds for detailed study. The following items might be included in the study guide:

a. Names

1) Common name(s)

2) Trade name(s)

3) Technical name

b. Composition

1) Chemical structure

2) Industrial preparation

3) Formulation of the insecticides

4) Analysis of mixtures - percentages of components

5) Physical state

a) Gas

b) Liquid

c) Solid

c. Intended use as an insecticide

1) Stomach poison

2) Contact poison

3) Fumigant

4) Combination

d. Toxicity

1) LD Ratings

LD_{50} the rating usually given as the designation for the dose lethal to 50 per cent of the test animals. Ratings may be expressed as <u>acute oral</u> or <u>acute dermal</u>.

2) LC Ratings

LC_{50} the rating often used to express the lethal concentration of inhalation toxicity.

3. ppm - parts per million of the daily diet for a specified number of days is sometimes used to express chronic toxicities.

e. Compatibility with other chemicals

f. Special additives used

1) Carriers

2) Solvents

3) Spreaders

4) Stickers

5) Extenders

g. Effectiveness as an insecticide

h. Problems

1) Application

2) Residue

3) Safety hazards

i. Synergists

1) Some chemicals have the property of greatly increasing toxicity of certain insecticides.

a) Most synergists have been used with pyrethrum or allethrin.

2) Sesamine

3) Piperonyl

4) Cyclonene

5) Sulfoxide

Suggested Teaching-Learning Activities

1. Prepare a kit of samples representative of the insecticides in common usage in the local and regional area. Classify and assemble according to the guides presented in the unit.

2. Prepare for use insecticides representative of the nine different types of formulations commonly used in insecticides.

3. As a class project, develop a master study guide of the pertinent properties and characteristics of selected insecticides. Assign the study of different insecticides to each member of the class and summarize the data reported back.

Suggested Instructional Materials and References

Fundamentals of Applied Entomology, Robert E. Pfadt, The MacMillan Company, New York, 1962.

Chemistry and Uses of Pesticides, E. R. de Ong, Reinhold Publishing Corporation, New York, 1956.

Modern Insecticides and World Food Production, Gunther, F. A., John Wiley & Sons, New York, 1960.

Insect Control by Chemicals, A. W. Brown, John Wiley & Sons, Inc., New York, 1951.

Insects, Yearbook of Agriculture, 1952.

Samples of Insecticides.

V. To gain a knowledge and understanding of the principles and concepts underlying the use of chemicals to prevent, control, or eradicate insects or similar pests which infest plants.

Teacher Preparation

Subject Matter Content

The ability of man to secure a high degree of control over insects is dependent not only upon his understanding of the technical nature of the chemical materials made use of in insecticides, but also upon his knowledge and understanding of the physical and biological world where use is made of these insecticides.

1. Insecticides are effective to the extent that they are used within specified conditions and applied in an acceptable manner. Variables of concern include:

   a. Selection of the appropriate insecticide

   b. Form to use

   c. Concentration to use

   d. Time to apply

   e. Method of application

   f. Placement

   g. Weather

   h. Safety hazards

2. Principles underlying the selection of insecticides.

   a. The lethal action of different kinds and types of insecticides.

      Insecticides affect the normal functions of cells, tissues, or systems of insects. Examples are:

      1) Arsenic destroys the mid-intestine of the insect

      2) Nicotine stimulates and then depresses the nervous system, paralysis follows.

      3) Pyrethrin, acts directly on the nervous system and paralysis is induced.

      4) Rotenone causes paralysis of the breathing mechanism.

5) Oils penetrate insect's breathing tubes and cause suffocation. Oils also penetrate tissues and poison them.

6) Dinitrophenal increases the metabolic rate to excessive levels.

7) DDT poisons nerve tissue and increases the consumption rate of oxygen.

All of the above effects result from the alteration of some chemical process in the insect. Many of these metabolic disturbances are not fully understood. Note that the mode of action of an insecticide does not refer to the way insecticides get inside the insect.

b. The selection of an insecticide is dependent upon various compatibilities of factors involved in its use.

1) Chemical incompatibility

2) Phytotoxic incompatibility - injury to plants

3) Physical incompatibility - change in physical form resulting in unstable and hazardous insecticides.

c. The toxicity of an insecticide is determined in part by the route by which the chemical enters the insect. The following order of toxicity has been observed:

1) By way of the cuticle - DDT > lindane > chlordane

2) By way of the mouth - lindane > DDT > chlordane

3) By way of the spiracle - chlordane > lindane > DDT

d. Considerations relative to the insects

1) Insects of different species vary in their susceptibility to injury from different insecticides.

2) The kinds of damage done to plants by insects or related pests.

a) Underground

b) Above ground - leaves, stems, flowers, fruit

c) Chewing, sucking, boring, egg laying

3) The accessibility of the insect

4) The development stage of the insect influences selection

a) Eggs - most susceptible just before hatching

b) Larvae and nymphs - easier to kill than pupae or adults

c) Pupae

d) Adults

e. Environmental conditions influence selection

1) Temperature - affects the rate at which the insecticide is absorbed into the insect's body and also the rate at which the insect detoxifies the insecticide inside its body. High temperatures for application and a lowering of temperature is desirable for most chemicals.

2) Relative humidity - affects drying rate

3) Rain - washing affect of water soluble sprays

4) Wind - makes application difficult - drift and uneven application

5) Time of the year

f. Considerations relative to the plant

1) Kind of plant

a) Variations exist according to the degree of susceptibility of different species and varieties to injury from different chemicals.

2) Stage of growth

3) Condition of the plant

a) Waxy surfaces

b) Heavy or light foliage

c) Amount of new growth

4) Use intended for the plant

a) Directly for animal use

b) Processed products for animal use

c) Direct human consumption

d) Processed products for human consumption

e) Ornamental use

3. Form and concentration of insecticide to use

a. Reasons for not using insecticides at full strength

1) Phytoxicity of materials at high concentrations

2) Difficulty of controlling dosage

3) Inability to secure uniform distribution

4) Presence of extreme safety hazards with some materials, i.e., parathion

b. Varying the form of insecticides

1) The physical nature of some toxic chemicals requires the addition of selected supplemental agents before they can be used satisfactorily. The following kinds of agents are used. (The instructor should develop a complete study guide regarding the characteristics and uses of chemicals used for each.)

a) Emulsifiers

b) Wetting and spreading agents

c) Suspending or dispersing agents

d) Deflocculating agents

e) Stickers or adhesives

f) Deposit builders

g) Correctives or safeners

2) In addition to those that are evident from the name, the following are other reasons for using supplemental agents

a) To increase penetration of material

-- into the plant or insect

-- throughout the foliage of the plant

b) Reduce hazards

-- Fire

-- Phytoxicity

-- Accidental poisoning

c) Secure greater product stability against affects of the sun, wind, rain, high temperature

d) Inerease or secure compatibility

e) Provide for storage

f) Improve ease and economy of application

g) Improve control of residues and levels of persistence

h) To take advantage of electrostatic charge

i) To offset (or take advantage of) physical and chemical changes that occur - absorption, and chemical reaction to form a new product

3) Considerations relative to the plant

a) Species

b) Part being treated

c) Age, size

d) Stage of growth

e) Intensity of foliage, fruit

f) Intended use of plant

4) Considerations relative to the insect

a) Susceptibility to form

b) Stage of development, growth

c) Part of plant infested

d) Type of damage done

4. Application of insecticide

Regardless of the form of the chemical used or the method by which it is applied, it is desirable to distribute the active

chemical in such a way that the insect will ingest or be exposed to it as quickly as possible after they appear and regardless of the part of the plant they inhabit. The pest, its food, host, or habitat must be covered with insecticide for a period long enough to secure control. This may or may not require total coverage of the plants over extended periods of time. The efficiency of pest control must be equated in terms of the number of insects killed, the cost of the insecticide used, and the cost of application.

a. Time of application

Only by understanding the principles and concepts pertaining to the timeliness of applying insecticides can program planning be completed. Instructors should direct the preparation of a study guide which treats important considerations of the local area. Some of the points to be considered in the preparation of the guide might include:

1) Considerations regarding the insect

a) At what point in time will the insect be present?

b) How long does the insect remain?

c) At what point in time will the insect be in a susceptible condition?

d) How is the insect affected by residues?

e) Will beneficial insects be harmed?

f) What is the location of the insect on the plant?

2) Considerations regarding the plant

a) Is the plant at a stage of growth where it is likely to be injured from the use of the insecticide?

b) What is the condition of the plant?

-- How much new growth has occurred since last application?

-- What is the density of the foliage?

-- What is the nature of the surface?

3) Other considerations

a) Temperature

b) Relative humidity

c) Rainfall/dew

d) Wind

e) Temperature inversions

f) Equipment available for application

g) Form and concentration of insecticide to be used

h) Kind of insecticide to be used

b. Kinds of applications (advantages/disadvantages)

1) Complete sprays - (principally for scale insects)

a) High pressure pumps provide for thorough, penetrating coverage

b) High pressure - high volume air blast

2) Droplet or mist sprays (insects and mites that move about freely)

3) Dusts

4) Aerosol fogs and smokes

5) Fumigants and gaseous applications

c. Application equipment

Very little standardization of equipment for applying insecticides has been made and it is therefore very difficult to set standards as to concentrations, rates of discharge, optimum deposits, or even the kind of equipment to use. Suggestions as to the actual use and calibration of application equipment are covered in another unit.

Suggested Teaching-Learning Activities

1. Demonstrate the three kinds of incompatibility encountered in using insecticides.

2. Apply various kinds of insecticides to a number of different kinds of insects. Have the students attempt to ascertain the cause of death. Categorize according to the disruption of a normal functioning of some body process.

3. Prepare a study guide as a class project of the characteristics and uses of various supplemental agents used in the formulations of insecticides.

4. Make appliaations of various insecticides on different plants in field laboratory exercises. Study the results, and evaluate in terms of the criteria examined in this unit.

Suggested Instructional Materials and References

Fundamentals of Applied Entomology, Robert E. Pfadt, The MacMillan Company, New York, 1962.

Chemistry and Uses of Pesticides, E. R. de Ong, Reinhold Publishing Corporation, New York, 1956.

Modern Insecticides and World Food Production, F. A. Gunther, John Wiley & Sons, Inc., New York, 1960.

Insect Control by Chemicals, A. W. Brown, John Wiley & Sons, Inc., New York, 1951. (This text has a comprehensive chapter on the pharmacology of poisons for insects.)

Compatibility charts.

Samples of supplemental agents.

Samples of straight insecticide materials.

VI. To understand what skills and abilities are essential in the general use of insecticides and to become familiar with practices and uses made of pesticides to control specific insects that infest plants in the local area.

Teacher Preparation

Subject Matter Content

One of the characteristics of the technician is the ability to make practical applications of theoretical knowledge and understanding. This unit seeks to move the learning sequence of the course to the point of program planning and its subsequent implementation.

1. The use of insecticides in general

   The decision to use insecticides or not to use them in connection with an insect control program is based upon many considerations. Decisions of this kind are influenced mostly by the economic nature of the possible alternatives although other considerations are now becoming of greater importance. But once the decision to use an insecticide is reached, the point is achieved where a program must now be planned which will draw upon the technical knowledge and understanding secured thus far in the course.

   General guidelines for planning a program in the use of insecticides are proposed. Extension of these guidelines to fit local and specific situations will be necessary.

2. Planning a program in the use of insecticides

   a. Determine what the situation is or what it is apt to be if insecticides are not used

      1) What is the threat - short-range, long-range?

      2) What risk is involved?

      3) What degree of control can reasonably be expected with, without the use of insecticides?

      4) What resources are available for use?

      5) What are the alternatives within the insecticide field?

   b. Establish goals and objectives

      1) What is desired, what is to be attempted, what accomplishments are to be sought?

a) Is what is to be attempted possible and attainable, yet challenging and worthwhile?

b) What tools of measurement are to be used?

2) Spell goals and objectives out in terms of:

a) The crop or crop product

b) The pest

c) The use of necessary inputs including insecticides

d) The control of other variables

c. Spell out ways and means to accomplish goals and objectives - devise a plan of action

1) Establish priorities and allocate resources

a) Determine the framework within which to operate, spell out limitations

b) Ascertain the specific use or uses to be made of insecticides

c) Make a selection of the insecticide(s) to be used

d) Plan for the use of the insecticide

-- Determine the form of insecticide to use

-- Ascertain the appropriate time application will be made

-- Select the method of application

-- Preparation of the chemical materials

-- Application

(Identify and be prepared to control as many of the other variables as possible that might affect the successful use of the pesticide. This would include items which affect the securing of uniform application, proper dosage, and effective coverage.)

e) Plan for an evaluation of results obtained

3. Aids to program planning

The field is replete with literature pertaining to the identification of insect pests and the use of insecticides to

control them. However, the advancements in the field of agricultural chemicals are so rapid that it is difficult for some publishers to provide current information. Many agencies find it necessary to furnish revised guides on a yearly basis.

a. The nature of the aids available

A wide variety of educational resource materials which deals with insects and insecticides is available and the student in agricultural chemicals technology has a choice of using many kinds. The U.S.D.A. through the Superintendent of Documents, the Cooperative Extension Service through each of the State Land Grant Institutions and most of the commercial chemical companies through their educational offices make available farmer's bulletins, agricultural information bulletins, leaflets, circulars, charts, guides, film strips, movies, and handbooks. Many texts and reference books dealing with entomology and insecticides are available from commercial publishing firms. Encountered are publications designed to provide information and data on:

1) The control of a specific pest (corn ear worm, cotton boll weevil, Japanese beetle, etc.)

2) The control of insects which infest a specific kind of plant (corn, alfalfa, wheat, peaches, walnuts, etc.)

3) The control of insects which infest similar plants (small grains, stone fruits, pasture grasses, bush berries, etc.)

4) The control of insects which infest plants belonging to a large group (field crops, orchard crops, ornamental crops, etc.)

5) The control of insects grouped according to:

   a) Order (Diptera, Lepidoptera, Orthoptera, etc.)

   b) Feeding method (chewing, sucking)

   c) Feeding habit (foliage, seed, fruit, root, etc.).

   d) Habitat (soil, aerial, combination)

6) The control of insect pests according to the use of chemicals which belong to specialized groups (organic, inorganic; chlorinated hydrocarbons, organic phosphates, oils, fumigants)

b. The central focus of most of these publications is upon:

1) The insect

2) The injury

3) The treatment or control

4) Comments as appropriate

Suggested Teaching-Learning Activities

1. Select a farm nearby and, with the cooperation of the owner, plan a comprehensive program of insect control.

2. Randomly select six or eight farms in the area and survey them as to the kind of insect control programs being practiced. Develop suggestions for improvements.

3. Devise a study guide and information sheet for the control of insects common to the area.

4. Invite representatives from local agricultural chemical firms to review approved practices of insect control in the area.

Suggested Instructional Materials and References

Fundamentals of Applied Entomology, Robert E. Pfadt, The MacMillan Company, New York, 1962.

Chemistry and Uses of Pesticides, E. R. de Ong, Reinhold Publishing Corporation, New York, 1956.

Modern Insecticides and World Food Production, F. A. Gunther, John Wiley & Sons, Inc., New York, 1960.

Insect Control by Chemicals, A. W. Brown, John Wiley & Sons, Inc., New York, 1951.

Entomology and insecticide publications as selected from the U.S.D.A., Agricultural Experiment Station, and Commercial Chemical Firms.

VII. To acquire the knowledge and skills needed to lawfully and safely handle, transport, store, and apply chemicals to prevent, control, or eradicate insects and similar pests which infest plants.

Teacher Preparation

Subject Matter Content

1. The concern for safety and the need for laws and controls in the field of insecticides.

   a. The user of a chemical material purchased for use to control insects cannot be expected to investigate or test the effectiveness of the product. The consumer of food grown under programs which included the use of insecticides must be assured that his health will not be impaired. The manufacturer of insecticides need protection from those who would make unfounded charges and accusations against his product. The interest of the general public in maintaining its natural resources, public institutions, and general well-being must be served. Laws have been enacted and regulations have been established at various levels of control to provide for these general needs.

   b. In passing these laws and establishing these regulations, legislative bodies, both federal and state, recognize the need of using insecticides to bring many agricultural food crops to maturity in a condition suitable for human consumption. The scope of these laws and regulations includes provisions to control the manufacture, sale, and use of substances intended to be used for preventing, destroying, repelling, mitigating, or controlling any insects, fungi, bacteria, weeds, rodents, predatory animals or any other form of plant or animal life which is a pest.

   c. Laws in different states require the registration of insecticides before they are offered for sale. This helps to prevent ineffective, fraudulent, or dangerous economic poisons from being marketed; it also helps enforcement. Information generally needed by most states for registration is suggested by the following:

      1) Chemical and physical

         a) Chemical name

         b) Chemical formula

         c) Chemical structure

d) Melting point

e) Vapor pressure

f) Solubilities

g) Odor

h) Density

i) Corrosive action

j) Flammability

k) Stability

l) Compatibility

m) Suitable diluents

n) Purities, grade

o) Mixtures to be available

2) Proposed usage

a) Name or names of the pest, pests, or type of pest for which the product affords control.

b) Name or names of the plants, crops, animals, or places to which product is to be applied.

c) Dilution recommended.

d) Preparation for use.

e) Method of application.

f) Rate of application.

g) Time of application.

h) Frequency of application.

3) Effectiveness

a) Experimental data available to demonstrate the effectiveness and suitability of the product for the intended usage. This must include pests treated on specific crops under climatic and soil conditions similar to that of State where registration is requested.

4) Hazards and cautions

a) The primary hazards to human beings who handle the compound, the particular parts of the body affected, the symptoms of poisoning, and their duration.

b) The acute toxicity to the particular species of animals on which it has been determined by inhalation, ingestion, and skin absorption.

c) The chronic toxicity to the particular species of animals on which it has been determined by inhalation, ingestion, and skin absorption.

d) Information on first aid or medical treatment of injured persons or animals.

e) Toxicity or harmfulness to valuable plants or animals on which it might be used.

-- Are certain plants sensitive?

-- Are certain animals sensitive?

-- Is it injurious to plants under certain conditions?

f) Other possible hazards

--Does it leave a stain or unsightly residue where these might be objectionable?

-- Does it impart an obnoxious taste to prepared foods, food crops, or to meat animals, as benzene hexachloride insecticides or coaltar disinfectants do?

-- Does it injure asphalt-tile floors as kerosene-base household sprays do?

-- Does it present a hazard to honey bees?

-- Is it particularly injurious to cats, fish, or caged birds?

-- Does it persist in the soil and injure crops subsequently planted?

-- Is it absorbed by dairy cattle and excreted in the milk?

-- Does it corrode or otherwise injure spray equipment?

-- Is it absorbed in treated foodstuffs, as parathion is absorbed in citrus peel and in mature olives?

-- Are precautions necessary in disposal of empty containers to avoid possible injury?

-- Are any special precautions necessary in cleaning, spraying or dusting equipment?

5) Analytical methods

a) Analytical methods available for

-- The technical material

-- Commercial products containing it with other ingredients

-- Spray and dust residues or other minute amounts on foodstuffs or other contaminated material

b) If analytical methods are not available, how is the quality of the manufactured product controlled?

6) Spray residue

a) If it is to be applied to foodstuffs, how may residues be removed?

d. It should be noted that reputable manufacturers of insecticides go to a great deal of effort to insure the safe and effective use of their products in support of state and federal legislation.

2. Provisions of the laws, controls, and regulatory acts pertaining to manufacture, sale, and use of insecticides.

a. To protect the people of the United States and their food supplies from foreign pests and other undesirable imports, the U. S. Congress has passed many laws. In addition to quarantine laws, our Congressmen have passed laws to establish tolerances for poisonous residues on foods, to regulate the sale of insecticides in such a manner as to protect the purchaser against fraud, to authorize and support extermination campaigns, and to provide facilities for investigational work needed to establish control practices by furnishing accurate information. The following are briefs of the four Federal Laws which govern the use of pesticides.

1) 1947 - Congress amended the USDA Pesticide Act to be known as Federal Insecticide, Fungicide & Rodenticide Act. It became effective June 25, 1948. Requirements were:

   a) Registration of all economic poisons with the USDA.

   b) Container label must contain name and address of manufacturer.

   c) Label must list name, brand or trade-mark of compound.

   d) The net contents.

   e) Statement of ingredients in the container, including the chemical name, or a well-known common name and the percentage of active and inert materials.

   f) Highly toxic materials must carry a poison lable with skull and crossbones, a warning statement and antidote.

2) Public Law 518 or Miller Amendment

   In passing this law, Congress amended the U. S. Pure Food, Drug and Cosmetic Act and added responsibilities to the USDA in registering economic poisons.

   USDA's responsibilities as stipulated in P.L. 518:

   a) Manufacturer must submit research results data with the application for registration by USDA.

   b) Manufacturer must show the product has a use and this use must be supported by experimental data showing pest(s) controlled, amount(s) used, number of applications and time of applications, and the amount of residue remaining on the crop(s) at harvest time.

   The USDA approval is needed before Food and Drug Administration will give consideration.

   The Food and Drug Administration (FDA) is a regulatory agency of the Department of Health, Education and Welfare. FDA accepts the pesticide application from USDA and manufacturer. They require:

   c) The manufacturer to supply pharmacological and toxicological data about the material in question. (Generally, the data from a minimum of two years of feeding experimental animals are needed to fulfill this requirement.)

d) FDA and, if needed, a specialist(s) appointed by the National Research Council consider the data in anticipation of setting a tolerance (whatever the tolerance, it is based on amount of residue remaining on crop at harvest time when used in accordance to the manufacturer's recommendation. At no time will a tolerance be set where the residue is less than 100 times the amount that will be hazardous to the health of the public. From this it is easily seen that each product is an individual situation and toxicities of any two materials cannot be compared on the tolerance given).

e) Four kinds of tolerances can be set

-- Exempt. The residue is not a hazard to public health.

-- Parts per million (PPM). This may be as low as 0.01 ppm to above 100 ppm. To ensure the safety of the public that an excess residue will not be present on the harvested crop a "limitation" of a number of days between last application and harvest is given. The limitation may set the number and time of applications and the amount of pesticide to be used per acre.

-- Zero. The manufacturer's application data may show that no residue is present at harvest time. The pesticide may be hazardous to public health. In this latter instance, FDA does not dictate that a pesticide cannot be used but if it is, there must be no residue on the harvested crop.

-- No Residue (N.R.). This tolerance is generally given to a pesticide that may have a use but insufficient data was submitted with the application. The pesticide can be used as long as no residue is on or in the harvested crop.

3) The Delaney Amendment or Public Law 85-929 governing "food additives" became effective September 6, 1958. In general it includes all additives used in production, hormones, lipstick compounds, etc., and that their use will be governed by the Miller Amendment to Public Law 518. One important phase of this amendment states that all materials that may be or are carcinogenic shall be given a zero tolerance. This was the basis for the "cranberry incident."

4) Public Law 86-139 governing defoliants, desiccants, plant regulators, and nematocides was passed by Congress and became effective March 5, 1960. This law places these materials under the Miller Amendment. Broadly speaking, the use of all agricultural chemicals and some other compounds, except fertilizers, are now governed by the Miller Amendment. No one is able to keep track of the over 4000 label tolerances. The best guide to prevent the misuse of any agricultural chemical is the instructions on the container label. Read the instructions thoroughly and follow the directions closely. Should the instructions permit use of the materials on barley, oats, and rye only, do not use it on wheat. The "by-products" of agriculture are a source of pesticide residues that are found in the fat of meat and milk. The list of by-products is long and include such items as alfalfa and clover chaff from seed production. Any agricultural crop that has been treated with a chlorinated hydrocarbon chemical generally contains a residue of the chemical or a degradation compound of the chemical. Treated by-products or any treated feed should not be fed to milk animals or to beef animals being fattened for slaughter. Some pesticides have been detected in animal tissues as long as six (6) months after the feeding of treated forage stopped. Another source of pesticide contaminated forage is from drifts at the time of application.

b. State laws - study as appropriate

c. Some of the salient requirements of federal and state legislation include:

1) Pre-testing

2) Registration

3) Coloring

4) Need for product

5) Labeling

6) Ingredient declaration

7) Guaranteed analysis

8) Appropriate warning

9) Directions for use

10) Name, address of manufacturer

d. In the field of pest control, the Department of Agriculture has major responsibilities for research, both on pesticides and on alternative methods of controlling pests that attack our crops, livestock, and forests, and for the registration of pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act, the Department is specifically charged to protect the public by considering both effectiveness and safety.

3. Federal insect and plant regulatory legislation

In addition to legislation enacted in the field of pesticides, the Congress has acted to protect against insects and plant disease. A summary of the acts follows:

a. Insect Pest Act of 1905 - Prohibits the importation or interstate movement, by any means of transportation, of any living insect that is notoriously injurious to cultivated crops.

b. The Plant Quarantine Act of 1912 - Most important of all legislation, this Act was enacted to protect the U. S. against the entry of dangerous insects, and plant diseases and to prevent the widespread distribution of such pests if they accidentally gain a foothold here. The entry of plants and plant products is regulated and interstate movement may be restricted by quarantine. Several important amendments to the act have been approved.

c. Mexican Border Act - The Secretary of Agriculture is authorized to regulate the entry from Mexico of all vehicles, freight, express, baggage, and other materials which may carry insect pests and plant diseases. Provisions are made for the legislation to be implemented and for fees to be collected for services required.

d. Export Certification Act - This act, a section of the "Department of Agriculture Organic Act of 1944," authorizes the Secretary of Agriculture to provide for the inspection of domestic plants and plant products to meet phytosanitary requirements of foreign countries.

e. Terminal Inspection Act - This act provides for inspection by State plant pest officials at mail terminals of plants and plant products moving interstate. This permits the States, in cooperation with the Post Office Department, to protect themselves against the entry of infested or infected products through the mails.

4. State plant and insect regulatory legislation

A number of State Legislatures have enacted legislation to protect their States against insects and plant disease. These

acts are in addition to the action of the Congress to protect the public interest. Study should be made of the legislative provisions applicable to the State with which one is concerned.

5. Working with insecticides safely

Insecticides kill insects because they affect a life process like respiration, digestion, circulation, and nerve reaction. Many of the insecticides in common use will also alter these same processes in man if enough of the chemicals should get into the body by mouth, with or without food; through the nose, by breathing vapors or particles of dust or liquids; or through the skin by absorption. Persons who plan to work with insecticides should become well informed regarding the safety hazards of each and how each should be handled, stored, and applied.

a. Sources of information regarding the safe use of insecticides

1) U.S.D.A.

2) County Agricultural Agents

3) State Departments of Agriculture

4) State Agricultural Colleges

5) Agricultural Experiment Stations

6) Cooperative Extension Service

7) Manufacturers of Insecticide

8) Vocational Agriculture Teachers

b. Insecticides differ in their effect on humans much as they do on insects. Those who work with these chemicals should be familiar with: (this serves to provide a basis for recognizing the dangers inherent in the use of insecticides)

1) Amounts likely to be toxic to man and domestic animals

2) Time before poisoning becomes apparent

3) The way in which insecticides act to cause poisoning

4) Symptoms of the poisoning itself

c. Aspects of safely transporting and storing insecticides

1) Store in original container

2) Keep away from children, animals, and feed stuffs

3) Destroy empty containers in a safe approved manner

4) Keep containers tightly closed except when preparing for use

5) Store where freezing will not occur

d. Aspects of safely applying insecticides

1) Read the label before opening the container

2) Use only at rates, at times, and for purposes stated on the label

3) Be familiar and comply with regulations pertaining to the use; the tolerances and residues allowable

4) Avoid eating or smoking when using insecticide

5) As necessary, wear protective clothing

a) Respirator and filters

b) Gloves (rubber or plastic as appropriate)

c) Goggles

d) Long-sleeve shirts, trousers, coveralls, coats

6) Wash face, arms, and hands thoroughly with soap and water after using insecticide

7) Wash clothing after each day's use

8) If chemicals are spilled on clothing or skin, wash both immediately.

9) Be alert to drift of the spray or dust material to crops or livestock which might be harmed

10) Be sure the insecticide material is thoroughly mixed before using

11) Keep an accurate record of dates, rates, and materials used

e. Aspects of properly caring for equipment

1) Always decontaminate a sprayer or duster that has been used for weed spraying before using it to apply insecticides.

2) Keep equipment in good repair by following a regular maintenance program.

f. First aid

1) Symptoms of poisoning

a) Abdominal cramps, tightness of chest, blurred vision, dizziness, nausea, diarrhea, or headache.

2) Action to take

a) Consult a doctor at once

b) Administer antidote if possible

g. Aspects relating to the general use of insecticides

1) Avoid injury to foraging bees. Be familiar with insecticides that are:

a) Highly toxic

b) Moderately toxic

c) Relatively non-toxic

2) Residue tolerances of importance

a) Insecticides considered safe

b) Insecticides exempt from the requirement of a tolerance when applied in accordance to good agricultural practice.

c) Insecticides with zero tolerance

h. Drifts

1) There is an important difference between drift and deposit, and drift and residue. All the material that crosses the neighbor's fence is drift. A portion of this drift stays on the neighbor's property is a residue when present on the harvested crop. If:

a) One pound of chemical landed on the acre, the hay would contain 500 ppm.

b) One ounce of chemical landed on the acre, the hay would contain 31 ppm.

c) One teaspoon of chemical landed on the acre, the hay would contain 5 ppm.

d) One teaspoon of chemical landed on 5 acres, the hay would contain 1 ppm.

e) One part per million is:

-- One inch in 16 miles

-- 1/2 city block in the distance around the world

-- One minute in 2 years

-- 1/4 mile in the distance to the moon

-- A postage stamp in the weight of a person

-- A 1-gram needle in a 1-ton hay stack

-- One good mouthful in all the food a person eats in a lifetime

2) So you see, when we think of a 7 ppm DDT it is in reality a very, very small amount. We must remember the law which Congressional Legislators passed states that hay intended for milking dairy animals and meat animals being fattened for slaughter shall be free of all DDT residues.

At the University of Illinois, researchers fed different amounts of Methoxychlor, DDT, Heptachlor, Aldrin, and Dieldrin to milk animals in their feed for 112 days. After one week the amount of the chemical in the milk increased throughout the 112 day period in almost every instance. The analysis of the decline of the chemical in the milk after the chemical was removed from the feed varied greatly. The methoxychlor was added at 900, 4000, and 8000 ppm in the feed and the residue was but 0.40 ppm the first day after the 112 days of 8000 ppm, and down to 0.07 ppm in two weeks. DDT added at 25 ppm was 0.39 ppm in the milk after two weeks. Heptachlor at 75 ppm was 0.81 ppm after 35 days. Aldrin at 1 ppm was 0.12 ppm after 35 days and dieldrin at 10 ppm was 0.28 after 35 days.

3) The pesticide drift residues can be reduced but everyone must do his part. They can be reduced by:

   a) Treating when there will be a minimum of drift.

   b) Treating up-wind from a neighbor's crop where residue would be a problem.

   c) Avoiding persistent residue materials.

   d) Using short-lived pesticides.

   e) Modifying spray equipment to apply coarse droplet sprays.

   f) Zoning of crops by farmers. Preventing hay and row crops and/or orchards being grown side by side.

   Everyone associated with the farming business and especially those associated with insecticides should each spring purchase a new edition of U.S.D.A. Agricultural Handbook No. 120, "Insecticide Recommendations of the Entomology Research Division for the Control of Insects Attacking Crops and Livestock." For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C., price 65 cents. Because some insecticides have many uses and because no one wants to have excessive residues on his crop at harvest time, always follow the container label instructions. Use insecticides only on the crops specified, in the amounts specified and at the times specified. This information is on the insecticide container label. If it is not, do not use it.

Suggested Teaching-Learning Activities

1. Invite the County Agricultural Commissioner, County Agricultural Extension Agent, or his representative to speak to the class on the lawful and safe use of insecticides.

2. Have each member of the class secure copies of various legislative acts and regulations and which pertain to the manufacture, sale, and use of insecticides, read them and discuss the meaning of their provisions.

3. Plan a farm pesticide safety program for your community or service area.

4. Assemble a safety demonstration kit and sponsor workshops and demonstration for interested groups of your community.

5. Examine a representative number of insecticide containers and note the specifics in each instance of the manufacturer complying with federal and state regulations.

6. Have a lawyer speak to the class on laws and regulations pertaining to insecticide use and cite court decisions on misuses.

7. Have a local custom applicator talk to the class on practical procedures on insecticide application and safety.

Suggested Instructional Materials and References

Insects, The Yearbook of Agriculture, 1952

Federal Acts:

Federal Food, Drug and Cosmetic Act (1939)

Federal Additives Amendment to the Federal Food, Drug and Cosmetic Act

Federal Insecticide, Fungicide, and Rodenticide Act (1947)

Miller Pesticide, Residue Amendment to the Federal Food, Drug and Cosmetic Act (1954)

P.L. 86-139, The Nematocide, Plant Regulator, Defoliant and Desiccant Amendment of 1959. (Amends 1947 Act.)

Copies of State and Local Regulations.

Agricultural Chemicals Safety, G. Van De Vanter. An instructional unit consisting of a student manual and an instructor guide.

A demonstration kit available for rent. California State Polytechnic College, San Luis Obispo, California. Student Manuals, $.50, Instructor's Guide, $3.50. Rental of kit (two-week rental), $25.00.

Handbook for Vegetable Growers, J. E. Knott, John Wiley & Sons, Inc., New York, 1962.

Insecticide Recommendations . . . Control of Insects Attacking Crops and Livestock, U.S.D.A. Agricultural Handbook No. 120, Superintendent of Documents, Washington, D.C.

Other sources of safety materials are as follows:

1. "The Agricultural Chemical Safety Program Kit," from the National Safety Council, 425 North Michigan Avenue, Chicago, Illinois 60611.

2. National Agricultural Chemicals Association
   1155 Fifteenth Street, N.W.
   Washington, D.C. 20005

   a. The Search for Abundance (12-page leaflet)

   b. Open Door to Plenty (64-page booklet)

3. Manufacturing Chemists' Association, Inc.
   1825 Connecticut Avenue, N.W.
   Washington, 9, D. C.

   a. Agricultural Chemicals - What They Are, How They Are Used (64-page booklet)

4. Florida State Board of Health
   Jacksonville, Florida

   a. Protect Your Family Against Poisoning (5-page leaflet)

5. Food and Drug Administration
   Washington, D.C. 20025

   a. Protecting Crops and Consumers (12-page leaflet)

   b. FDA - Consumer Information Materials (5-page leaflet)

   c. Dennis Takes a Poke at Poison (16-page comic book)

   d. Read the Label on Foods, Drugs, Devices, Cosmetics, and Household Chemicals (36-page booklet)

   e. Facts for Consumers - Pesticide Residues (16-page booklet)

   f. Report: FDA's Pesticide Residue Program, Miscellaneous Publication 410.66-1-1

   g. Aids to Compliance, A Catalog of FDA Industry Information Materials, Leaflet 26, Feb. 1966.

6. U. S. Public Health Service
   Washington, D. C. 20025

   a. Pesticides (8-page leaflet)

7. U. S. Department of Agriculture
Washington, D.C. (and Florida
Agricultural Extension Service)

   a. Safe Use of Pesticides in the Home, in the Garden (USDA leaflet PA-589, 8 pages)

   b. Homemakers and Home Gardeners - Use Pesticides Safely (USDA leaflet PA-594, 4 pages)

8. Prepared cooperatively by:
National Agricultural Chemicals Association
National Safety Council
U. S. Department of Agriculture
Food and Drug Administration
National Vo-Ag Teachers Association
Manufacturing Chemists' Association

   a. Chemicals in Agriculture - A Guide for Adult and Youth Programs in Agricultural Chemical Safety (4-page leaflet)

9. Florida Agricultural Extension Service
University of Florida
Gainesville, Florida 63210

   a. Poisons in Your House (42 color slides)

   b. Safe Use of Pesticides (31 color slides)

   c. Safe Use of Pesticides (color film-22 min)

   d. The Unseen Harvesters (color film-28 min)

10. Manufacturing Chemists' Association, Inc.
1825 Connecticut Avenue, N.W.
Washington, D.C. 20009

   a. Facts About Pesticides (film strip-13 min)

   b. Points on Pesticides (film strip-13 min)

Sources of Suggested Instructional Materials and References

References

Brown, A. W., Insect Control by Chemicals, John Wiley & Sons, Inc., New York, 1951.

de Ong, E. R., Chemistry and Uses of Pesticides, Reinhold Publishing Corporation, New York, 1956.

Gunther, F. A., Modern Insecticides and World Food Production, John Wiley & Sons, Inc., New York, 1960.

Knott, J. E., Handbook for Vegetable Growers, John Wiley & Sons, Inc., New York, 1962.

Metcalf, Flint, Metcalf, Destructive and Useful Insects, 4th Edition, McGraw-Hill Book Company, New York, 1962.

Pfadt, Robert E., Fundamentals of Applied Entomology, The MacMillan Company, New York, 1962.

Thompson, W. T., Agricultural Chemicals, The Simmons Publishing Company, Davis, California, 1964.

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Agricultural Chemicals, Manufacturing Chemists' Association, Inc., Washington, D.C., 1963.

Entomology and Insecticide Publications as Selected from U.S.D.A. Agricultural Experiment Station and Commercial Firms.

Farm Chemicals Handbook, Meister Publishing Co., 37841 Euclid Avenue, Willoughby, Ohio, 1966.

Federal Acts:
Federal Food, Drug and Cosmetic Act (1939)
Federal Additives Amendment to the Federal Food, Drug, and Cosmetic Act.
Federal Insecticide, Fungicide, and Rodenticide Act (1947)
Miller Pesticide, Residue Amendment to the Federal Food, Drug, and Cosmetic Act (1954)
P.L. 86-139 The Nematocide, Plant Regulator, Defoliant and Desiccant Amendment of 1959. (Amends 1957 Act.)

Guides, Handbooks, Fact Sheets, Bulletins, Leaflets and Circulars from Federal and State Agencies and Commercial Firms.

Instructional Materials--Continued

Insects, Yearbook of Agriculture, U.S.D.A., U. S. Government Printing Office, Washington, D.C., 1952.

The Necessity, Value and Safety of Pesticides, L. A. McLean, Secretary, Velsicol Chemical Company, Chicago.

Working Samples of Insecticides and Supplemental Agents

Insecticide Recommendations . . . for the Control of Insects Attacking Crops and Livestock, U.S.D.A. Agricultural Handbook No. 120, Superintendent of Documents, Washington, D.C.

Films

"The Unseen Harvester," DuPont 16mm sound film.

"Facts About Pesticides," record and film strip, Manufacturers Chemists' Association, Inc., 1925 Connecticut Ave., N.W., Washington, D.C.

THE CENTER FOR RESEARCH AND LEADERSHIP DEVELOPMENT
IN VOCATIONAL AND TECHNICAL EDUCATION
THE OHIO STATE UNIVERSITY
980 KINNEAR ROAD
COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name_____

2. Name of school_____State_____

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
_____Ornamental Horticulture--Service Occupations
_____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report_____

5. To what group (age and/or class description) was this material presented?____
_____

6. How many students:
a) Were enrolled in class (total) _____
b) Participated in studying this module _____
c) Participated in a related occupational work experience program while you taught this module _____

7.

Actual time spent teaching module:		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE	NOT APPROPRIATE
8. The suggested time allotments given with this module were:		
9. The suggestions for introducing this module were:		
10. The suggested competencies to be developed were:		
11. For your particular class situation, the level of subject matter content was:		
12. The Suggested Teaching-Learning Activities were:		
13. The Suggested Instructional Materials and References were:		
14. The Suggested Occupational Experiences were:		

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

_____ _____
(Date) (Instructor's Signature)

_____
(School Address)